TITLE: Pre-Operative Screening and Post-Operative Monitoring of Adults with Obstructive Sleep Apnea: A Review of Clinical Effectiveness and Guidelines

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CONTEXT AND POLICY ISSUES

Obstructive sleep apnea (OSA) is characterized by abnormal breathing during sleep, resulting in hypoxemia during the night, recurrent awakenings, sleep fragmentation, and drowsiness during the day.[1] In OSA, inspiratory efforts are ineffective due to partial or complete blockage of the upper airway, resulting in apneas (the absence of airflow at the nose and mouth for at least 10 seconds) and hypopneas (a greater than 50% reduction in airflow also for at least 10 seconds).[1] Obesity is the primary risk factor for sleep apnea; other risk factors include advancing age, sex (male), vocal cord and craniofacial abnormalities, and enlarged tonsils or tongue.[1] Polysomnography (PSG), an overnight study of sleep state, breathing, and oxygenation, is considered the gold standard for the diagnosis of OSA.[1] The Apnea Hypopnea Index (AHI) is derived from PSG and quantifies the number of abnormal respiratory events per hour of sleep. An AHI of five or more, in conjunction with either unexplained daytime sleepiness or two or more symptoms of OSA, is the diagnostic criteria for OSA.[2]

General population prevalence estimates of OSA range from 2% to 26%; however, higher rates have been reported in surgical populations.[2] An estimated 80% of individuals with OSA may be undiagnosed, which can be problematic for surgical patients, where OSA can increase the risk of cardiovascular and pulmonary complications.[3] Moreover, lack of recognition of OSA precludes appropriate peri-operative planning and post-operative care and monitoring. Screening surgical patients for OSA with PSG may be impractical, however, as it is expensive, may be limited in availability, has long wait times, and is inconvenient for patients.[4] In studies of surgical populations, the patient refusal rate of PSG is high.[2] The use of screening questionnaires, such as the STOP-Bang Questionnaire, the American Society of Anesthesiologists(ASA) checklist, the Flemons criteria, and the Berlin Questionnaire, provide an alternative approach to identifying patients at risk for OSA .[4] The clinical utility of such questionnaires is dependent on their diagnostic accuracy and ability to identify patients at risk for post-surgical complications.

This report will review the evidence of clinical effectiveness of tools used to screen the pre-surgical adult patients for OSA and identify guidelines that address post-surgical monitoring of patients with OSA.

RESEARCH QUESTIONS

1. What is the clinical effectiveness of tools used to screen the pre-surgical adult patient with possible obstructive sleep apnea?

2. What are the guidelines for post-surgical monitoring of adult patients with suspected and confirmed obstructive sleep apnea?

3. What are the guidelines associated with patients bringing and using their own CPAP machines into the hospital when undergoing surgery?

KEY FINDINGS

Limited evidence suggests that the STOP-Bang questionnaire may be an appropriate method of screening for OSA in patients scheduled for surgery. The ASA Checklist may also be appropriate, but was only assessed in two studies. The false negative rates may, however, be high with these questionnaires.

One evidence-based guideline presented alternatives for post-operative monitoring of patients increased risk of respiratory compromise from OSA.

Two evidence-based guidelines supported the use of the patient's own CPAP machine in hospital, but did not provide any specific recommendations for implementation of such a policy.

METHODS

Literature Search Strategy

A limited literature search was conducted on key resources including PubMed, The Cochrane Library (2014, Issue 2), University of York Centre for Reviews and Dissemination (CRD) databases, ECRI (Health Devices Gold), Canadian and major international health technology agencies, as well as a focused Internet search. No methodological filters were applied to limit retrieval for question 1. A filter was used to limit retrieval to guidelines for questions 2 and 3. Where possible, retrieval was limited to the human population. The search was also limited to English language documents published between January 1, 2010 and February 18, 2014.

Rapid Response reports are organized so that the evidence for each research question is presented separately.

Selection Criteria and Methods

One reviewer screened the titles and abstracts of the retrieved publications to determine if they were relevant to the review. The same reviewer evaluated the full-text publications for the final article selection into the report based upon the criteria identified in Table 1.

Table 1: Selection Criteria

Population	Adults with suspected or diagnosed obstructive sleep apnea (OSA) undergoing surgery with general anaesthesia
Intervention	Q1 - Screening tools for sleep apnea (including, but not limited to) • Berlin Questionnaire • STOP-Bang Questionnaire • ASA checklist • Any newer questionnaires Q2 - Guidelines for monitoring post-operative patients Q3 - Guidelines for bringing patient's own CPAP machine
Comparator	None or any other screening tool, nurses monitor patients with suspected OSA for 3 hours (to track vital signs, etc.)
Outcomes	Q1 -Clinical effectiveness (including safety, harms and benefits), validity, reliability, standardization Q2 and Q3 - Guidelines
Study Designs	Health technology assessments (HTA), systematic reviews (SR), meta-analyses (MA), randomized controlled trials (RCTs), non-RCTs, and guidelines

HTA - Health technology assessment; MA - Meta-analysis; Q - Question; RCT - Randomized controlled trial; SR - Systematic review

Exclusion Criteria

Articles were excluded if they did not meet the predefined selection criteria as outlined in Table 1 or were outside of the timeframe of the search. As well, review articles that were not based upon a systematic literature search, duplicate publications of the same study, and guidance documents or consensus statements that did not include a description of the methodology used in their development or not clearly evidence-based were excluded from the report. Studies that assessed the diagnostic accuracy of prediction models derived from physiological parameters were also excluded.

Critical Appraisal of Individual Studies

The studies of diagnostic accuracy were critically appraised using the QUADAS II instrument.[5] Non-randomized studies were critically appraised using the SIGN 50 Checklist for Cohort Studies.[6] Guidelines were evaluated using the AGREE II tool.[7] Items from these tools were considered in assessing the quality of the included literature and results of the critical appraisal are discussed narratively. Numeric scores from these tools were not calculated.

SUMMARY OF EVIDENCE

Quantity of Research Available

The literature search yielded 347 citations. After screening citations from the database and grey literature searches, 36 potentially relevant studies were obtained for full-text review. Eleven clinical studies and two evidence-based guidelines[8,9] met the selection criteria and were

selected for inclusion into the review. The PRISMA flowchart in Appendix 1 details the process of the study selection.

Of the 11 non-randomized studies were included in the review, four were cross-sectional studies[10-13] that evaluated the diagnostic accuracy of screening questionnaires for OSA and seven were longitudinal cohort studies[14-20] that evaluated clinical outcomes in patients categorized as high-risk for OSA using a screening questionnaire.

Summary of Study Characteristics

1. *What is the clinical effectiveness of tools used to screen the pre-surgical adult patient with possible obstructive sleep apnea?*

Details of the characteristics of included studies of clinical effectiveness of screening tools for OSA can be found in Appendix 2, Table 3.

Four cross-sectional studies evaluated the diagnostic accuracy of the STOP-Bang questionnaire in screening for OSA in adults undergoing surgery.[10-13] One study included only patients who were obese or morbidly obese.[11] Samples sizes ranged from 367 to 746 patients. All studies were North American, with three being carried out in Canada[11-13] and one in the United States.[13] In two studies, the diagnostic accuracy of the STOP-Bang questionnaire as a screening tool for OSA was assessed using a single cut-point (score of ≥ 3).[10,12] The diagnostic accuracy of multiple cut-points was assessed in two studies.[11,13] In all studies, the reference test was PSG, the gold standard for diagnosing OSA. Outcomes included sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and area under the receiver operator characteristic (ROC) curve.

Seven longitudinal cohort studies, four prospective[14-16,18] and three retrospective,[17,19,20] assessed the relationship between a positive or high risk OSA screening result on one or more questionnaire according to different cut-points and criteria and the development of post-operative complications. Three studies were performed in the United States,[16,19,20] two in Singapore,[15,17] one in Italy,[14] and one in Turkey.[18] Duration of follow-up ranged from 48 hours to one year following surgery; however, the duration was not clearly reported in three of the seven studies.[15,17,19] Three studies included patients scheduled for elective surgery,[14,15,20] three included general surgery patients,[16,17,19] and one included only patients undergoing coronary artery bypass graft (CABG).[18] The types of surgeries performed were not reported in three studies,[16,17,19] and was variable across studies that did report on this characteristic. Where ASA Physical Function Score was reported, most patients were in category 2 or 3. In the high-risk OSA category, greater proportions of patients had ASA scores that were in category 3 or 4 compared to those considered low risk of OSA. Sample sizes ranged from 180 to 14,962 patients. Most studies compared outcomes of patients categorized as high-risk for OSA using one or more screening tool to outcomes of patients who were categorized as low risk on the same tool. The STOP-Bang questionnaire was evaluated in four studies,[14-16,20] but different cut-points for the high-risk categorization was used in each study. The ASA checklist was used in two studies,[17,19] with one study comparing a protocol that confirmed the ASA checklist screening result with PSG prior to proceeding to surgery to proceeding to surgery without confirmation of the result.[17] The Berlin Questionnaire was evaluated in one study.[18] Outcomes included post-operative complications (respiratory, cardiac and neurologic), critical care admission, and mortality. One study also reported on diagnostic accuracy of the ASA checklist.[19]

2. *What are the guidelines for post-surgical monitoring of adult patients with suspected and confirmed obstructive sleep apnea?*

One evidence-based guideline from the American Society of Anesthesiologists[9] provided recommendations on the post-surgical monitoring of patients at risk of respiratory compromise from OSA. The guidelines were an update of a previous guideline from 2006. A systematic literature search was performed to identify new literature. The identified literature was graded and recommendations were developed based upon consensus (Appendix 2, Table 4).

3. *What are the guidelines associated with patients bringing and using their own CPAP machines into the hospital when undergoing surgery?*

Two evidence-based guidelines provided recommendations about use of personal CPAP machines in hospital.[8,9] Both guidelines were American-based, identified the relevant literature through systematic search methods, and formulated recommendations based upon graded literature. (Appendix 2, Table 4)

Summary of Critical Appraisal

1. *What is the clinical effectiveness of tools used to screen the pre-surgical adult patient with possible obstructive sleep apnea?*

Details of the critical appraisal of the included clinical effectiveness studies are summarized in Appendix 3, Table 5. A case-control design was avoided in all four included diagnostic studies; however, it was unclear for three studies if a consecutive sample of patients was recruited.[11-13] The exclusion criteria were few and appeared to be appropriate in all four studies.[10-13] The cut-point for a positive screen for OSA using the STOP-Bang was pre-specified for those studies using a single threshold.[10,12] A key strength of the included diagnostic studies was the use of PSG as the reference test,[10-13] which is considered the gold standard for diagnosing OSA. However, in three studies, two different methods of performing PSG were used (portable home PSG and PSG carried out in a sleep lab).[11-13] A common limitation to the four studies was a lack of reporting of the time that elapsed between administering the STOP-Bang (index test) questionnaire and performance of PSA (reference test).[10-13] As well, not all patients who were administered the STOP-Bang underwent PSA, so the assessment of diagnostic accuracy of the STOP-Bang was not based upon the entire sample that was screened.[10-13] A final common limitation was a lack of clarity around blinding of the results of the PSG when interpreting STOP-Bang results[10-13] In some cases, PSG was obtained from a previous medical records, so it is possible that there was knowledge of the result when administering the STOP-Bang questionnaire.

All of the included cohort studies had clearly defined research questions, had comparable source populations, and defined outcomes clearly (Appendix 3, Table 5).[14-20] There were some limitations to the statistical analyses, with some studies not controlling for potential confounders[15,17,18] or failing to report confidence intervals.[16-19] Without controlling for known factors, such as ASA Physical Function Score, obesity and age, which are also associated with surgical risk, it difficult to determine if the observed association between a high-risk OSA screen on a questionnaire and surgical complications was confounded by such factors. Further, it is not possible to control for all potential confounders in a cohort study, which can limit the ability to make strong conclusions about the association between exposure (a positive screen for OSA) and outcome (surgical complications). Follow-up was incomplete in some studies or unclear if it

was complete.[14,16,17,19] As well, outcome assessment was often unblinded to OSA screening status or blinding could not be ascertained.[14,16,18]

2. *What are the guidelines for post-surgical monitoring of adult patients with suspected and confirmed obstructive sleep apnea?*

Details of the critical appraisal of the included guidelines are summarized in Appendix 3, Table 6. The American Society of Anesthesiologist guideline[9] had a well-defined scope and purpose, involved national organizations representing most specialties that provide care for patients with OSA, was rigorous in its methodology for development, but did not describe a procedure for updating. The recommendations were clear, unambiguous and easily identifiable. The guideline did, however, have some limitations with respect to applicability, as it did not describe barriers or facilitators to implementation or application and did not report auditing criteria.

3. *What are the guidelines associated with patients bringing and using their own CPAP machines into the hospital when undergoing surgery?*

The Institute for Clinical Systems Improvement guideline met all of the quality assessment criteria with the exception of one (Appendix 3, Table 6).[8] It was unclear if the views of the funding body could potentially influence the content of the guideline. The scope and purpose of the guideline were well-defined, physicians, nurses, pharmacists, other healthcare professionals and patients were involved in development, development was rigorous, systematic methods for identifying and selecting evidence were described and the evidence was linked to the recommendations. As well, the recommendations were specific and unambiguous and easily identifiable. A plan for implantation and monitoring or auditing was described. The critical appraisal of the American Society of Anesthesiologist guideline[9] has been summarized previously.

Summary of Findings

Main findings of included studies are summarized in detail in Appendix 4, Table 7.

1. *What is the clinical effectiveness of tools used to screen the pre-surgical adult patient with possible obstructive sleep apnea?*

With a cut-point of ≥ 3 points, the sensitivity of the STOP-Bang as a screening tool for OSA of any severity in surgical patients ranged from 82.6% to 95.8%.[10-13] Using the same cut point, the specificity ranged from 9.1% to 40.3%, the PPV ranged from 76% to 85.0% and the NPV from 28.6% to 54.5% across studies. With higher cut-points, the sensitivity and NPV decreased, while the specificity and PPV increased.[11,13] The area under the ROC curve was 0.63 (95% CI: 0.55 to 0.71) in obese patients,[11] 0.59 (95% CI: 0.47 to 0.71) in morbidly obese patients,[11] and 0.65 (95% CI: 0.61 to 0.70) in patients undergoing general surgery or surgery on selected units.[13]

A positive screen for OSA using the STOP-Bang questionnaire with a cut-point of ≥ 3 was associated with an increased risk of post-operative cardiovascular or pulmonary complications after adjusting for age, obesity and ASA Physical Status Score [OR = 11.40 (95% CI: 1.18 to 110.47); P=0.03].[20] A cut-point of ≥ 5 on the STOP-Bang was associated with an increased risk of post-operative complications (OR 3.98, 95% CI: 1.69 to 9.37), difficult intubation (OR 1.86, 95% CI: 1.37 to 2.51) and difficult mask ventilation (OR 2.06, 95% CI: 1.51 to 2.83).[14] Scores on

the STOP-Bang exceeding 4 points were also associated with an increased risk of critical care admission.[15] While the STOP-Bang score was also associated with ICU admission and one-year mortality, the cut-point used in that study was not reported.[16]

For the ASA Checklist, outcomes (cardiac, respiratory, and neurological complications, and duration of Post-Analgesia Care Unit stay) were similar for patients who were screened for OSA using the ASA Checklist only and for those patients who had OSA confirmed via PSG.[21] As well, patients categorized as high-risk for OSA based on the ASA Checklist had higher rates of a composite respiratory post-operative complication endpoint and a number of secondary endpoints, including hypoxia, re-intubation, and ICU admission.[19] The estimated sensitivity and specificity for the ASA score were 95.1% and 52.2%, respectively.[19]

A positive screen for OSA using the Berlin Questionnaire was associated with an increased risk of post-operative atrial fibrillation,[18] but not ICU admission or one-year mortality.[16]

For the Flemons Index, a positive screen for OSA did not predict ICU admission, but was associated with increased risk of one-year mortality.[16]

2. *What are the guidelines for post-surgical monitoring of adult patients with suspected and confirmed obstructive sleep apnea?*

With respect to post-surgical monitoring, the American Society of Anesthesiology Task Force on Perioperative Management of Patients with Obstructive Sleep Apnea[9] recommends the following:

> "Hospitalized patients who are at increased risk of respiratory compromise from OSA should have continuous pulse oximetry monitoring after discharge from the recovery room. *[Category B3-B evidence, indicating beneficial effects based on noncomparative observational studies with descriptive statistics]*
>
> Continuous monitoring may be provided in a critical care or stepdown unit, by telemetry on a hospital ward, or by a dedicated, appropriately trained professional observer in the patient's room.
>
> Continuous monitoring should be maintained as long as patients remain at increased risk.*** If frequent or severe airway obstruction or hypoxemia occurs during postoperative monitoring, initiation of nasal CPAP or NIPPV should be considered." (p274)[9]
>
> *** Intermittent pulse oximetry or continuous bedside oximetry without continuous observation does not provide the same level of safety. (p274)[9]

3. *What are the guidelines associated with patients bringing and using their own CPAP machines into the hospital when undergoing surgery?*

Two guidelines with recommendations about using a personal CPAP machine in hospital are summarized in Table 2. The guidelines both recommend that patients bring their own CPAP machine to the hospital, but do not provide any additional guidance on policies and procedures around doing so.

Table 2: Guidelines for personal CPAP machine use in hospital

Guideline, Publication Year	Recommendations
American Society of Anesthesiologists, 2014[9]	"When feasible, CPAP or noninvasive positive pressure ventilation (with or without supplemental oxygen) should be continuously administered to patients who were using these modalities preoperatively, unless contraindicated by the surgical procedure. Compliance with CPAP or noninvasive positive pressure ventilation may be improved if patients bring their own equipment to the hospital."p.276 (no level of evidence or grading reported)
Institute for Clinical Systems Improvement, 2012[8]	"Clinicians should remind patients who have been formally diagnosed with obstructive sleep apnea and have an oral appliance or continuous positive airway pressure equipment to bring their appliance or equipment with them on the operative day." P.7 High quality of evidence, strong recommendation

Limitations

The four studies of diagnostic accuracy included in this report assessed only the STOP-Bang questionnaire. One additional longitudinal study also reported on the diagnostic accuracy of the ASA checklist as a screening tool for OSA, but no evidence of diagnostic accuracy was identified for the other questionnaires. However, it should be noted that the present review captured literature published after 2010. A previous Rapid Response report on the same topic that searched the literature between 2005 and 2010[22] identified two systematic reviews of diagnostic accuracy of the Berlin Questionnaire, STOP and ASA Checklist in identifying surgical patients with sleep apnea. It was concluded that while these measures could be useful, they may have high false negative rates, that the data was sparse, and there was limited evidence to support the use of these screening tools before the surgery. While the diagnostic studies in the current review used an appropriate reference standard (PSG), they did not report the duration of time that elapsed between the screening questionnaire and performance of PSG, which could potentially affect agreement between the two tests. As well, three studies used two different methods of administering PSG (the reference test) and while they reported that home PSG is expected to produce similar results as PSG performed in a sleep laboratory, it is unclear if some participants would be misclassified using home PSG. This could potentially impact the observed diagnostic accuracy of the screening questionnaires. For most studies of diagnostic accuracy, it was unclear if a consecutive sample of patients was included and not all patients underwent PSG. These factors may increase the risk of bias in selecting the samples.

Studies that assessed the association between the STOP-Bang questionnaire and surgical outcomes used different cut-points, so it is difficult to assess the consistency of the association across studies. As well, the surgical populations differed in terms of the type of surgery and underlying surgical risk, which also makes it difficult to compare the strength of association across studies. Further, there was potential for bias and confounding in the included longitudinal cohort studies. Three studies did not control for potential confounders in the statistical analyses and in those studies that did, a limited number of potential confounders were included. Without

controlling for other factors that could affect the underlying risk for surgical complications, it is difficult to attribute the observed association only to the positive OSA screening result. There was a lack of clarity with respect to the proportion of patients who agreed to participate in the prospective cohort studies and the proportion of participants with complete outcome data was unclear in several studies. As such, there was a risk of selection bias into the prospective cohort studies and a risk for attrition bias. Finally, there was a risk of ascertainment bias in studies with unblinded outcome assessment, although for some outcomes, such as mortality, the risk would likely be small.

The two included evidence-based guidelines were methodologically rigorous and made clear recommendations with respect to the use of personal CPAP machines in hospital, but provided little guidance about policies, procedures or protocols for doing so. One evidence-based guideline was identified that addressed post-operative monitoring of patients with OSA.

CONCLUSIONS AND IMPLICATIONS FOR DECISION OR POLICY MAKING

Evidence from cross-sectional diagnostic and longitudinal cohort studies published since 2010 suggests that the STOP-Bang questionnaire may be an appropriate method of screening for OSA in patients scheduled for surgery. A previous Rapid Review summarized the evidence of the diagnostic accuracy of the STOP (a shorter questionnaire than the STOP-Bang), Berlin Questionnaire and ASA Checklist in OSA and found they while they may have some utility, thy had high false negative rates meaning some at-risk individuals may be missed in the screening process. Based on more recently published information, scores on the STOP-Bang of less than three points suggest a lower risk of OSA and lower risk of post-operative complications, but the studies in which these trends were observed had some methodological limitations which may reduce the level of confidence in their findings. Further, based upon the included evidence, the optimal cut-point for use of the STOP-Bang questionnaire in clinical practice remains unclear. The ASA Checklist also appeared to be an appropriate pre-operative screening test for OSA, based upon its diagnostic accuracy and association with post-operative complications, but was only assessed in two studies. A previous Rapid Response report which identified literature published prior to 2010 found its false negative rate to be high. This limits the ability to make strong conclusions about its adoption in practice. Based upon the included evidence, no conclusions can be made about the clinical effectiveness of the Flemons Index or Berlin Questionnaire as screening tools for OSA in surgical patients.

One included guideline recommended alternate strategies for monitoring patients with an increased risk of respiratory compromise from OSA, but emphasized the need for continuous observation while the patient remained at an increased level of risk. Two guidelines supported the use of the patient's own CPAP machine in hospital, but did not provide any specific implementation or policy recommendations for adopting this practice.

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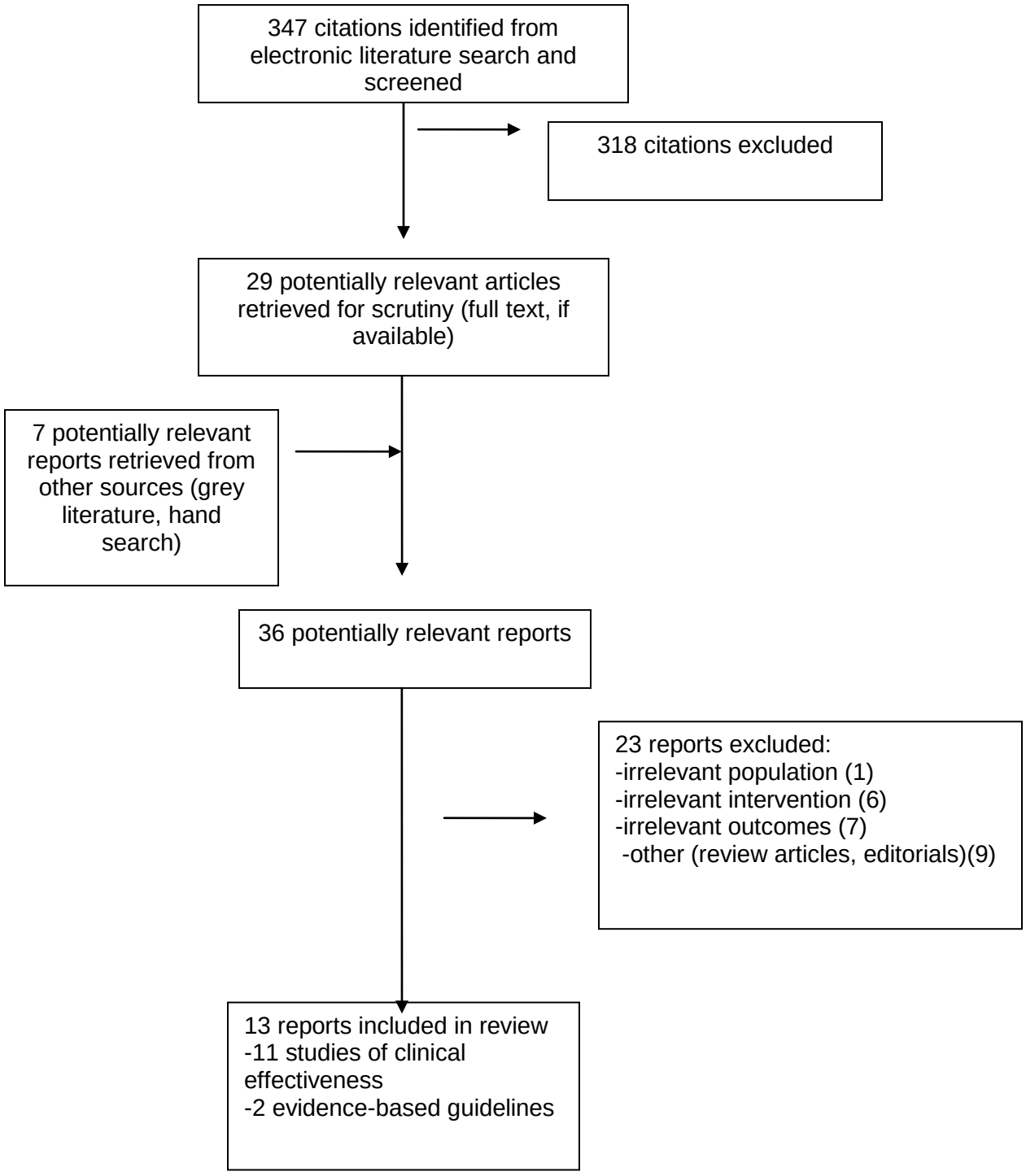
APPENDIX 1: Selection of Included Studies



APPENDIX 2: Summary of Individual Study Characteristics

Table 3: Table of Characteristics of Included Clinical Studies

First Author, Publication Year, Country	Study Design, Length of Follow-up****	Patient Characteristics, Sample Size (n)	Intervention	Comparator	Clinical Outcomes
Cross-sectional diagnostic studies					
Kulkarni, 2014[10] United States	Non-RCT Cross-sectional design	Patients aged 18 and older undergoing evaluation for general surgery n=367	STOP-Bang Questionnaire (≥ 3 points cut point)	PSG	PPV Sensitivity
Chung, 2013a[11] Canada	Non-RCT Cross-sectional design	Patients aged 18 and older scheduled for elective procedures in general surgery, gynecology, orthopedics, urology, plastics or ophthalmology n=310 obese patients n=140 morbidly obese patients	STOP-Bang Questionnaire (multiple cut-points)	PSG	Sensitivity Specificity PPV NPV Area under ROC curve
Chung, 2013b[12] Canada	Non-RCT Cross-sectional design	Patients aged 18 and older scheduled for elective procedures in general surgery, gynecology, orthopedics, urology, plastics or ophthalmology n=384	STOP-Bang Questionnaire (multiple cut-points)	PSG	Sensitivity Specificity PPV NPV
Chung, 2012[13]	Non-RCT	Patients aged 18 and older scheduled for elective	STOP-Bang Questionnaire (≥ 3	PSG	Sensitivity Specificity

First Author, Publication Year, Country	Study Design, Length of Follow-up****	Patient Characteristics, Sample Size (n)	Intervention	Comparator	Clinical Outcomes
Canada	Cross-sectional design	procedures in general surgery, gynecology, orthopedics, urology, plastics or ophthalmology n=746	points -individual scores)		PPV NPV Area under ROC curve
Longitudinal Studies					
Corso, 2013[14] Italy	Non-RCT Prospective cohort study 48 hours post-surgery	Adults scheduled for elective surgery n=3452	STOP-Bang Questionnaire (≥ 5 points) ASA Physical Status Score 1 – 5.5% 2 – 45.9% 3 – 44.8% 4 – 3.7% Type of Surgery Abdominal – 12.7% Head and Neck – 17.8% Thoracic – 23.1% Genitourinary – 22% Vascular – 11.7% Orthopedic – 12.7%	STOP-Bang Questionnaire (< 5 points) ASA Physical Status Score 1 – 29.3% 2 – 45.9% 3 – 23.1% 4 – 1.7% Type of Surgery Abdominal – 17.1% Head and Neck – 42.2% Thoracic – 10.3% Genitourinary – 14.5% Vascular – 6.5% Orthopedic – 9.4%	Post-operative complications, difficult intubation, difficult mask ventilation

First Author, Publication Year, Country	Study Design, Length of Follow-up****	Patient Characteristics, Sample Size (n)	Intervention	Comparator	Clinical Outcomes
Chia, 2013[15] Singapore	Non-RCT Prospective cohort study Duration of follow-up unclear	Adults scheduled for elective surgery n=5342 ASA Physical Status Score 1 – 45.5% 2 – 45.5% 3 – 10.2% 4 – 0.8% Type of Surgery Ear, nose, throat – 8.9% General or urology – 38.1% Oral maxillo-facial – 29.9% Orthopedic – 23.1%	STOP-Bang Questionnaire (> 0 points)	STOP-Bang Questionnaire (0 points)	Critical care admission
Lockhart, 2013[16] United States	Non-RCT Prospective cohort 1 year post-operatively	Adult surgical patients n=14,962 ASA Physical Status Score 1 – 6.1% 1E to 2 – 50.1% > 2 – 43.9% Type of surgery not reported.	STOP-Bang STOP BQ Flemons Index (High risk* categorization on each)	STOP-Bang STOP BQ Flemons Index (Low risk categorization on each)	Admission to ICU versus PACU Mortality
Chong, 2013[17] Singapore	Non-RCT Retrospective cohort Duration of follow-up unclear	Patients undergoing surgery who were seen at a pre-anaesthesia clinic n=463	Positive screen on the ASA checklist* without confirmation using PSG (screening only group)	PSG confirmed sleep apnea (PSG-confirmed group)	Post-operative cardiovascular, respiratory and neurologic complications

First Author, Publication Year, Country	Study Design, Length of Follow-up****	Patient Characteristics, Sample Size (n)	Intervention	Comparator	Clinical Outcomes
		ASA Physical Status Score 1 – 45.5% 2 – 45.5% 3 – 10.2% 4 – 0.8% Type of surgery not reported.	ASA Physical Status Score† 1 – 0% 2 – 12.5% 3 – 57.6% 4 – 0% Type of surgery not reported.	ASA Physical Status Score† 1 – 2.0% 2 – 18.4% 3 – 79.6% 4 – 0% Type of surgery not reported.	Duration of stay in PACU Agreement between ASA and PSG
Mungan, 2013[18] Turkey	Non-RCT Prospective cohort study Duration of post-operative stay	Patients with preoperative sinus rhythm undergoing primary isolated CABG ASA Physical Status Score not reported.	Berlin Questionnaire (High risk for OSA***)	Berlin Questionnaire (Low risk for OSA)	Post-operative atrial fibrillation
Munish, 2012[19] United States	Non-RCT Retrospective cohort study Duration of follow-up unclear	Patients aged 18 to 80 undergoing general surgery (outpatient or inpatient) n=3593 Type of surgery not reported.	ASA Checklist (≥ 5 points) ASA Physical Status Score 1 – 1% 2 – 22.1% 3 – 55.7% 4 – 20.5% 5 – 0.7%	ASA Checklist (< 5 points) PSG if available and performed in the past five years (for assessment of diagnostic accuracy) ASA Physical Status Score 1 – 2.1% 2 – 31.4% 3 – 50.8% 4 – 15.3%	Post-operative complications Adverse events Diagnostic accuracy** • Sensitivity • Specificity • PPV • NPV • Area under ROC curve

First Author, Publication Year, Country	Study Design, Length of Follow-up****	Patient Characteristics, Sample Size (n)	Intervention	Comparator	Clinical Outcomes
				5 – 0.3%	
Vasu, 2010[20] United States	Non-RCT Retrospective cohort study Three days post-operatively	Adults undergoing elective surgery n=180	STOP-Bang Questionnaire (≥ 3 points - cut point) ASA Physical Status Score 1 – 1.8% 2 – 33.9% 3 – 64.3% Type of Surgery Orthopedic – 35.4% Head and neck – 15.2% Abdominal – 12.6% Gynecologic – 12.6% Genitourinary – 6.3% Otorhinolaryngologic – 5.1% Cardiothoracic – 1.3% Vascular – 1.3% Others – 10.1%	STOP-Bang Questionnaire (< 3 points) ASA Physical Status Score 1 – 15.2% 2 – 46.8% 3 – 38.0% Type of Surgery Orthopedic – 41.1% Head and neck – 19.6% Abdominal – 16.1% Gynecologic – 3.6% Genitourinary – 7.1% Otorhinolaryngologic – 1.8% Cardiothoracic – 3.6% Vascular – 3.6% Others – 3.6%	Post-operative complications

ASA – American Society of Anesthesiologists; BQ – Berlin Questionnaire; CABG – Coronary artery bypass graft; ICU – Intensive care unit; NPV – Negative predictive value; OSA – Obstructive sleep apnea; PACU – Post-anesthesia care unit; PPV - positive predictive value; PSG – Polysomnography; RCT - Randomized controlled trial; ROC – Receiver operator characteristic

* Cut points for categorization as high or low risk not reported; ** For only those patients with PSG available from the past five years; *** Positive on two or more categories; ****Not applicable to cross-sectional studies; † For Severe OSA patients

Table 4: Characteristics of Included Evidence-Based Guidelines

Target Population	Scope, Purpose, Country of Origin	Evidence Collection, Selection and Synthesis	Evidence Quality and Strength of Recommendation	Formulation of Recommendations
American Society of Anesthesiologists, 20149				
Inpatients and outpatients undergoing sedation and analgesia in an operating room or other location	Perioperative management of patients with confirmed or suspected OSA United States	Review of literature published after the previous guideline. Categorization and grading of evidence	**Evidence Based** **Category A –** RCT with comparative findings **Category B –** Observational studies or RCTs without pertinent comparison groups **Opinion-based Category A –** Expert opinion **Category B –** Membership opinion **Category C –** Informal opinion	Developed via a multistep process that included consensus on literature selection and summary, expert consultation, input on draft recommendations, and survey and consensus building for finalization of the Guidelines.
Institute for Clinical Systems Improvement, 20128				
Adults and pediatric surgery undergoing elective surgical procedures	"Evaluation for elective, non-high-risk operative procedures for adult and pediatric patients"p.8 Guideline recommendations pertain to the time frame prior to the patient arriving for surgery. United States	Systematic literature search, selection of evidence and grading of evidence	Evidence graded as high, medium or low quality according to the GRADE system Recommendations rated as weak or strong according to the GRADE system	Developed by a working group comprised of 6 to 12 members representing physicians, nurses, pharmacists, other healthcare professionals relevant to the topic

GRADE - Grading of Recommendations Assessment, Development and Evaluation; OSA – Obstructive sleep apnea; RCT – Randomized controlled trial

APPENDIX 3: Summary of Critical Appraisal

*Table 5: Critical Appraisal of Included Studies of Clinical Effectiveness**

First Author, Publication Year	Strengths	Limitations
Cross-sectional Diagnostic Studies (QUADAS II)5		
Kulkarni[10] 2014	• Enrolled a consecutive sample of patients • Did not use a case control design • Exclusion criteria were appropriate • Threshold for positive screen on STOP-Bang pre-specified • Reference standard was PSG, the gold standard, which was likely to classify patients appropriately • All patients received the same reference standard	• Unclear if STOP-Bang was interpreted without knowledge of the reference standard (PSG) • Unclear if PSG was administered without knowledge of the STOP-Bang result • Time interval between STOP-Bang and PSG was unclear • Not all patients screened with the STOP-Bang underwent PSG, so not all patients were included in the analysis
Chung[12] 2013	• Did not use a case control design • Exclusion criteria were appropriate • Threshold for positive screen on STOP-Bang pre-specified • Reference standard was PSG, the gold standard, which was likely to classify patients appropriately • Reference standard (PSG) interpreted without knowledge of index test (STOP-Bang)	• Methods of sample selection unclear (consecutive, random, or other method) • Unclear if index test (STOP-Bang) was interpreted without knowledge of the reference standard (PSG) • Time interval between STOP-Bang and PSG was unclear • Not all patients screened with the STOP-Bang underwent PSG, so not all patients were included in the analysis • Reference standard was not the same for all patients as some had home PSG and others had PSG performed at a sleep laboratory.
Chung[11] 2013	• Did not use a case control design • Exclusion criteria were appropriate • Reference standard was PSG, the gold standard, which was likely to classify patients appropriately • Reference standard (PSG) interpreted without knowledge of index test (STOP-Bang)	• Methods of sample selection unclear (consecutive, random, or other method) • Unclear if index test (STOP-Bang) was interpreted without knowledge of the reference standard (PSG) • Time interval between STOP-Bang and PSG was unclear • Not all patients screened with the STOP-Bang underwent PSG, so not all patients were included in the analysis • Reference standard was not the

First Author, Publication Year	Strengths	Limitations
		same for all patients as some had home PSG and others had PSG performed at a sleep laboratory.
Chung[13] 2012	• Did not use a case control design • Exclusion criteria were appropriate • Reference standard was PSG, the gold standard, which was likely to classify patients appropriately • Reference standard (PSG) interpreted without knowledge of index test (STOP-Bang)	• Methods of sample selection unclear (consecutive, random, or other method) • Unclear if index test (STOP-Bang) was interpreted without knowledge of the reference standard (PSG) • Time interval between STOP-Bang and PSG was unclear • Not all patients screened with the STOP-Bang underwent PSG, so not all patients were included in the analysis • Reference standard was not the same for all patients as some had home PSG and others had PSG performed at a sleep laboratory.
Longitudinal (Cohort) Studies (SIGN-50 Checklist for Cohort Studies)6		
Corso, 2013[14]	• Appropriate and clearly focused research question • Source populations comparable • Reported percentage who agreed to participate in each group • Definitions of outcomes were clearly reported • Reliable assessment of OSA using cut-points established in the literature • Potential confounders accounted for in the analysis • Confidence intervals reported with the statistical analysis	• Unclear if follow-up was complete • Assessment of outcomes was not blinded to results of OSA screening, but this was acknowledged as a limitation
Chia, 2013[15]	• Appropriate and clearly focused research question • Source populations comparable • Follow-up was complete • Definitions of outcomes were clearly reported • Used STOP-Bang score, which appears to be a reliable screen for OSA • Confidence intervals reported with the statistical analysis	• Did not report percentage who agreed to participate in each group • Unclear if potential confounders were not accounted for in the analysis

First Author, Publication Year	Strengths	Limitations
Lockhart, 2013[16]	• Appropriate and clearly focused research question • Source populations comparable • Definitions of outcomes were clearly reported • Potential confounders accounted for in the analysis	• Did not report percentage who agreed to participate in each group • Unclear if follow-up was complete, so also unclear if a comparison between those with complete and missing outcome data was needed. • Unclear is outcome assessor was blinded to OSA status based upon the various screening questionnaires • Cut-points used to categorize as having OSA on the questionnaires were not reported. • No confidence intervals reported with the statistical analysis for some outcomes
Chong, 2013[17]	• Appropriate and clearly focused research question • Source populations comparable • Reported percentage who agreed to participate in each group • Definitions of outcomes were clearly reported	• Follow-up appeared to be incomplete, but difficult to determine due to reporting • No comparison between patients who had complete and missing outcomes • Reliability of ASA Checklist for screening unclear as cut-point used was not reported • Potential confounders were not accounted for in the analysis • No confidence intervals reported with the statistical analysis
Mungan, 2013[18]	• Appropriate and clearly focused research question • Source populations comparable • Reported percentage who agreed to participate in each group • Follow-up was complete • Definitions of outcomes were clearly reported • Clear definition of OSA using the Berlin Questionnaire	• Unclear if outcome assessment was blind to OSA status • Potential confounders were not accounted for in the analysis • No confidence intervals reported with the statistical analysis
Munish, 2012[19]	• Appropriate and clearly focused research question • Source populations comparable • Reported percentage who agreed to participate in each group	• Unclear if follow-up was complete • No rationale for cut-point used to categorize patients as high or low risk for OSA • No confidence intervals reported with the statistical analysis

First Author, Publication Year	Strengths	Limitations
	• Definitions of outcomes were clearly reported • Outcome assessment was blind to OSA-status • Potential confounders accounted for in the analysis	
Vasu, 2010[20]	• Appropriate and clearly focused research question • Source populations comparable • Follow-up was complete • Definitions of outcomes were clearly reported • Used STOP-Bang score, which appears to be a reliable screen for OSA • Potential confounders accounted for in the analysis • Confidence intervals reported with the statistical analysis	• None identified

* Items that were 'not applicable' based upon study design or other characteristics are not reported
ASA – American Society of Anesthesiologists; OSA – Obstructive sleep apnea; PSG – Polysomnography

Table 6: Critical Appraisal of Included Evidence-Based Guidelines

First Author, Publication Year	Strengths	Limitations
Evidence-Based Guidelines (Agree II)7		
American Society of Anesthesiologists, 2014[9]	• Overall objective clearly described • Population to whom the guideline is meant to apply is specifically described • Relevant professional groups included in guideline development • Target users of the guideline clearly defined • Systematic methods used for literature search • Selection criteria for the evidence described clearly • Strengths and limitations of the body of evidence clearly described • Method for formulating recommendations clearly described. • Health benefits, side effects, risks considered in formulating recommendations • Explicit link between recommendations and supporting literature • External review of guideline by experts • Specific and unambiguous recommendations • Options for management clearly described • Recommendations easily identifiable • Competing interests of develop group members stated (none)	• Health questions covered by guideline not specifically described • Unclear if views and preferences of the target population were sought • Did not provide procedure for updating guidelines • Did not describe facilitators and barriers to application of guideline • Did not provide tools and advice for implementation • Did not consider resource implications of applying recommendations • Did not provide monitoring and auditing criteria • Unclear if views of the funding body would influence the content of guideline
Institute for Clinical Systems Improvement, 2012[8]	• Overall objective clearly described • Health questions covered by guideline specifically described • Population to whom the guideline is meant to apply is specifically described • Relevant professional groups included in guideline development • Views and preferences of the target population were sought • Target users of the guideline clearly defined • Systematic methods used for literature search • Selection criteria for the evidence described clearly • Strengths and limitations of the body of evidence clearly described • Method for formulating recommendations clearly described. • Health benefits, side effects, risks considered in formulating	• Unclear if views of the funding body would influence the content of guideline

First Author, Publication Year	Strengths	Limitations
	recommendations • Explicit link between recommendations and supporting literature • External review of guideline by experts • Procedure for updating provided • Specific and unambiguous recommendations • Options for management clearly described • Recommendations easily identifiable • Description of facilitators and barriers to application of guideline • Tools and advice for implementation provided. • Resource implications of applying recommendations considered • Monitoring and auditing criteria provided • Competing interests of develop group members stated (none)	

APPENDIX 5: Results

Table 7: Table of Main Study Findings and Authors' Conclusions

First Author, Publication Year	Main Study Findings		Authors' Conclusions
Kulkarni, 2014[10]	OSA of any severity*** PPV – 76% Sensitivity – 92.1% Moderate to severe OSA Sensitivity – 96% Severe OSA Sensitivity – 100%		A significant number of patients presenting for general surgery are at high risk of OSA. No conclusions with respect to the clinical utility of the STOP-Bang.
Chung, 2013a[11]	**Obese Patients % (95% CI)**	**Morbidly Obese Patients % (95% CI)**	The STOP-Bang score was validated in the obese and morbidly obese surgical patients. Obese STOP-Bang score of 3 has a sensitivity of 90% and a high PPV of 85 % to identify OSA. Morbidly obese STOP-Bang score of 4 has high sensitivity across the entire spectrum of OSA severity.
	≥ 3 Points Sensitivity 90.5 (86.2 to 93.8) Specificity 28.1 (16.4 to 39.7) PPV 84.8 (80.0 to 88.9) NPV 40.0 (24.9 to 56.7) **≥ 4 Points** Sensitivity 68.8 (62.7 to 72.4) Specificity 45.6 (32.4 to 59.3) PPV 84.9 (79.2 to 89.5) NPV 24.8 (16.9 to 34.1) **≥ 5 Points** Sensitivity 44.3 (38.1 to 50.6) Specificity 73.7 (60.3 to 86.5) PPV 88.2 (81.3 to 93.2) NPV – 23.0 (17.1 to 29.7) **≥ 6 Points** Sensitivity 22.5 (17.5 to 28.2) Specificity 87.7 (76.3 to 94.9) PPV	**≥ 3 Points** Sensitivity 95.8 (90.4 to 98.6) Specificity 9.1 (1.1 to 29.2) PPV 85.0 (77.7 to 90.6) NPV 28.6 (3.7 to 71.0) **≥ 4 Points** Sensitivity 78.8 (70.3 to 85.8) Specificity 22.7 (7.8 to 45.4) PPV 84.5 (76.4 to 90.7) NPV 16.7 (5.6 to 34.7) **≥ 5 Points** Sensitivity 51.7 (42.3 to 61.0) Specificity 63.6 (40.7 to 82.8) PPV 88.4 (78.4 to 94.9) NPV 19.7 (11.2 to 30.9) **≥ 6 Points** Sensitivity 29.7 (21.6 to 38.8) Specificity 86.4 (65.1 to 97.1) PPV	

First Author, Publication Year	Main Study Findings		Authors' Conclusions
	89.1 (78.8 to 95.5) NPV 20.3 (15.5 to 25.9) **Area Under ROC Curve** 0.63 (0.55 to 0.71)	92.1 (78.6 to 98.3) NPV 18.6 (11.6 to 27.6) **Area Under ROC Curve** 0.59 (0.47 to 0.71)	
Chung, 2013b[12]	**% (95% CI)** Sensitivity – 82.6 (75.2 to 88.5) Specificity – 37.0 (24.3 to 51.3) PPV – 77.0 (69.4 to 83.5) NPV – 45.5 (30.4 to 61.2)		The STOP-Bang is a highly sensitive tool for screening for sleep OSA.
Chung, 2012[13]	**≥ 1 Points (%)** Sensitivity - 98.8 Specificity - 2.5 PPV - 68.7 NPV - 50.0 **≥ 2 Points (%)** Sensitivity - 95.7 Specificity - 17.8 PPV - 71.6 NPV - 65.6 **≥ 3 Points (%)** Sensitivity - 84.1 Specificity - 40.3 PPV - 75.3 NPV - 54.0 **≥ 4 Points (%)** Sensitivity - 60.0 Specificity - 60.6 PPV - 76.7 NPV - 41.2	**≥ 5 Points (%)** Sensitivity - 36.3 Specificity - 79.7 PPV - 79.4 NPV - 36.7 **≥ 6 Points (%)** Sensitivity - 17.7 Specificity - 91.5 PPV - 81.8 NPV - 34.0 **≥ 7 Points (%)** Sensitivity - 7.1 Specificity - 97.5 PPV - 85.7 NPV - 32.7 **≥ 8 Points (%)** Sensitivity - 0.8 Specificity - 98.7 PPV - 57.1 NPV - 31.5 **Area Under ROC Curve:** 0.65 (95% CI: 0.61 to 0.70)	A STOP-Bang score of < 3 will allow the healthcare team to rule out patients without OSA. A STOP-Bang score of 5 to 8 will help to identify patients with increased risk of OSA.
Corso, 2013[14]	**High Risk vs Low Risk for OSA – OR (95% CI)** Post-operative complications 3.98 (1.69 to 9.37) Difficult intubation 1.86 (1.37 to 2.51) Difficult mask ventilation 2.06 (1.51 to 2.83)		Patients who are high risk for OSA have an increased risk for post-operative complications. The STOP-Bang score may help establish strategies to reduce the risk of adverse events.
Chia, 2013[15]	**Critical Care Admission – OR (95% CI)***		The STOP-Bang score may

First Author, Publication Year	Main Study Findings	Authors' Conclusions
	STOP-Bang = 1 1.2 (0.7 to 1.9) STOP-Bang = 2 1.5 (0.9 to 2.6) STOP-Bang = 3 1.4 (0.7 to 2.6) STOP-Bang = 4 2.2 (1.1 to 4.6) STOP-Bang = 5 3.2 (1.2 to 8.1) STOP-Bang ≥ 6 5.1 (1.8 to14.9)	be used to stratify the need for postoperative critical care.
Lockhart, 2013[16]	**ICU Admission – OR (95% CI)** High risk STOP-Bang 1.4 (1.2 to 1.7) High risk STOP 1.4 (1.1 to 1.6) High risk Berlin 1.2 (0.998 to 1.4) High risk Flemons 1.2 (0.88 to 1.5) **30 day Mortality** No statistically significant differences between high and low risk on any screening tools **1 year Mortality** High risk STOP-Bang: 7.45% Low risk STOP-Bang: 4.13% P < 0.0001 High risk STOP: 7.57% Low risk STOP: 5.28% P < 0.0001 High risk Berlin: 6.11% Low risk Berlin: 5.57% P=NS High risk Flemons: 6.91% Low risk Flemons: 4.96% P < 0.0001	Additional research is needed to investigate which method of screening for OSA pre-operatively is both practical and effective.
Chong, 2013[17]	Cardiac complications Screening only – 3.3% PSG-confirmed OSA – 2.3% P=0.34 Respiratory complications Screening only – 14.3% PSG-confirmed OSA – 12.5% P=0.96 Neurological complications Screening only – 0.6% PSG-confirmed OSA – 0% P=1.0	"With a stratified risk management protocol, it is safe to proceed with elective surgery without delay for formal confirmation of OSA with PSG."p.118

First Author, Publication Year	Main Study Findings	Authors' Conclusions
	PACU Duration of Stay- Minutes (mean ± SD) Screening only – 102 ± 101 PSG-confirmed OSA – 141 ± 93 P=0.02 Agreement (kappa) Mild OSA – 0.96 Moderate OSA – 0.97 Severe OSA – 0.93 Overall OSA – 0.95	
Mungan, 2013[18]	POAF – 58% High Risk OSA on Berlin No POAF – 34% High Risk OSA on Berlin P=0.044	"Preoperative questionnaire-based diagnosis of OSA by the Berlin Questionnaire is useful in predicting POAF and can be easily incorporated into routine screening of surgical patients undergoing CABG operation." p.41
Munish, 2012[19]	Composite respiratory post-operative complication High risk OSA – 25.4% Low risk OSA – 17.4% P < 0.01 Hypoxia High risk OSA – 16.6% Low risk OSA – 10.2% P < 0.01 Tracheal Re-Intubation High risk OSA – 4.9% Low risk OSA – 0.9% P < 0.01 ICU Admission High risk OSA – 28.3% Low risk OSA – 21.6% P < 0.01 No statistically significant differences for MI, ischemia, AF, CVA, death. ASA Score versus PSG Sensitivity - 95.1% Specificity - 52.2% NPV** 98.5% Area under ROC curve – 0.80	"Patients with OSA have a higher incidence of post-operative adverse events, implying a need to develop specific management strategies for OSA patients. The ASA checklist offers a highly sensitive tool to identify the patients at a higher risk of OSA during the perioperative period."p.227

First Author, Publication Year	Main Study Findings	Authors' Conclusions
Vasu, 2010[20]	Post-operative complications (cardiac or pulmonary) High Risk OSA – 19.6% Low risk OSA – 1.3% P < 0.001 OR† = 11.40 (95% CI: 1.18 to 110.47); P=0.03 Diagnostic Accuracy of STOP-Bang for Complications (3 or higher) Sensitivity – 91.7% Specificity – 63.4% PPV – 19.6% NPV – 98.7% Area under ROC curve – 0.82	"A STOP-Bang score ≥ 3 is associated with an increased risk of postoperative complications. The STOP-Bang questionnaire is a convenient and useful screening tool for identifying those at increased risk of postoperative complications."p.1024

AF – Atrial fibrillation; ASA – American Society of Anesthesiologists; BQ – Berlin Questionnaire; CABG – Coronary artery bypass graft; CI – Confidence interval; CVA – Cardiovascular accident; ICU – Intensive care unit; MI – Myocardial infarction; NPV – Negative predictive value; OR – Odds ratio; OSA – Obstructive sleep apnea; PACU – Post-anesthesia care unit; PPV - positive predictive value; POAF – Post-operative atrial fibrillation; PSG – Polysomnography; RCT - Randomized controlled trial; ROC – Receiver operator characteristic

* Compared to STOP-Bang score of 0
** At a prevalence of 10%
*** The negative predictive value and specificity could not be calculated as there were no true negatives
† OR – Adjusted for ASA class, obesity and age